Back-to-Back Correlations of High p_T Hadrons From Dynamical Model Calculations

See also Poster "High p_T 19"

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OUTLINE

- Introduction
- Hydro+jet model
- Back-to-back correlations of high pT hadrons
- Summary

References

T.Hirano and Y.Nara,
Phys.Rev. C**66**, 041901(2002);
Phys.Rev.Lett. **91**, 82301(2003);
Phys.Rev. C68, 064902(2003);
nucl-th/0307015.

1. Introduction

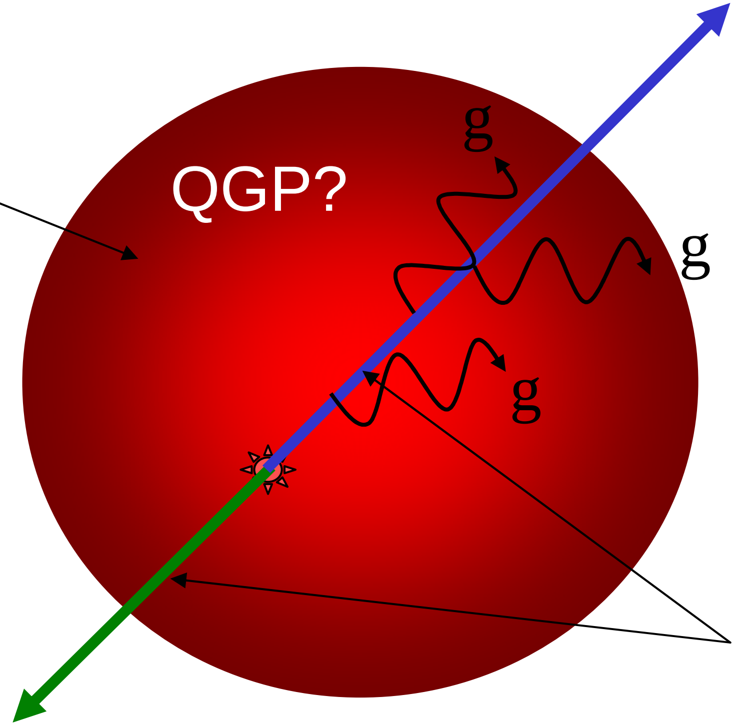
1. Jet quenching

Gyulassy, Plumer ('90)
Wang, Gyulassy ('92)
and a lot of work

Hot and dense matter produced in heavy ion collisions

Not static, but dynamic!

Need a *dynamic* model



correlate ?

2. Jet acoplanarity
(transverse momentum imbalance)

Bjorken ('82)
Appel ('86)
Blaizot, McLerran ('86)
Rammerstorfer, Heinz ('90)

2. Model

- Jet quenching
- Jet acoplanarity

Interaction between soft and hard is *important!*

Hydro + Jet model

Soft (hydrodynamics)

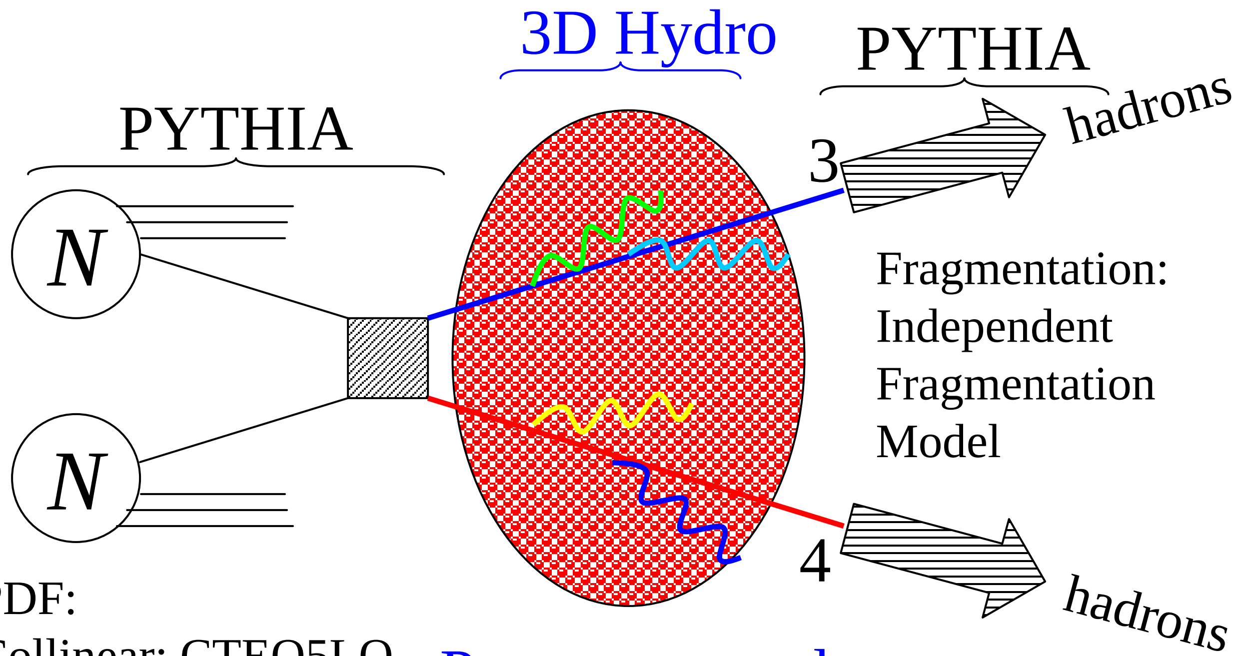
- Space-time evolution of matter
- Phase transition between QGP and hadrons
- Particle spectra in low p_T region

Hard (mini-jets)

- Production of (mini-)jets
- Propagation through fluid elements
- Fragmentation into hadrons

Interaction between fluids and mini-jets through parton energy loss

3. PYTHIA(+Hydro)



PDF:
Collinear: CTEQ5LO
k_T: Gaussian

Parton energy loss

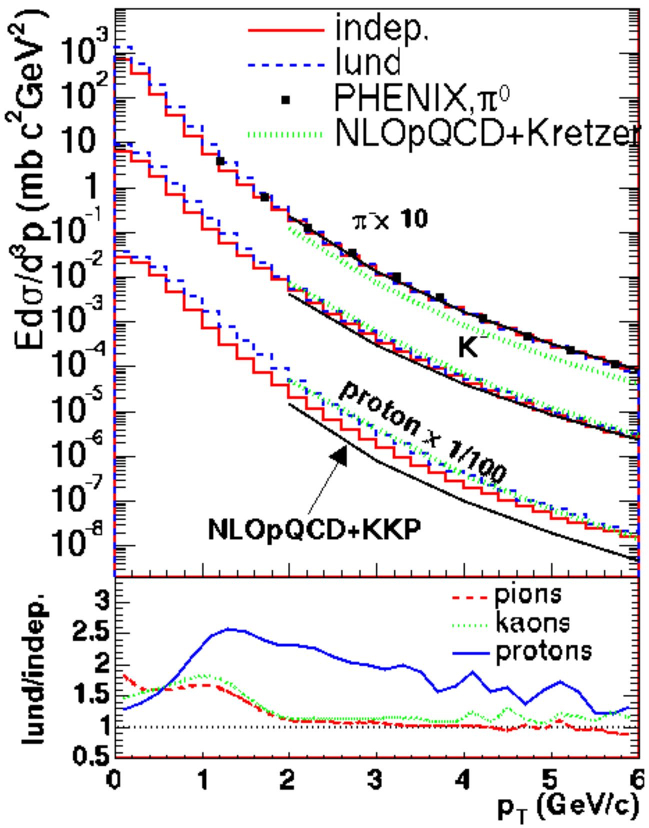
pQCD LO:

$$q + q' \to q + q', \; q + \bar{q} \to q + \bar{q}$$
$$q + \bar{q} \to g + g, \; q + g \to q + g$$
$$g + g \to g + g, \; g + g \to q + \bar{q}$$

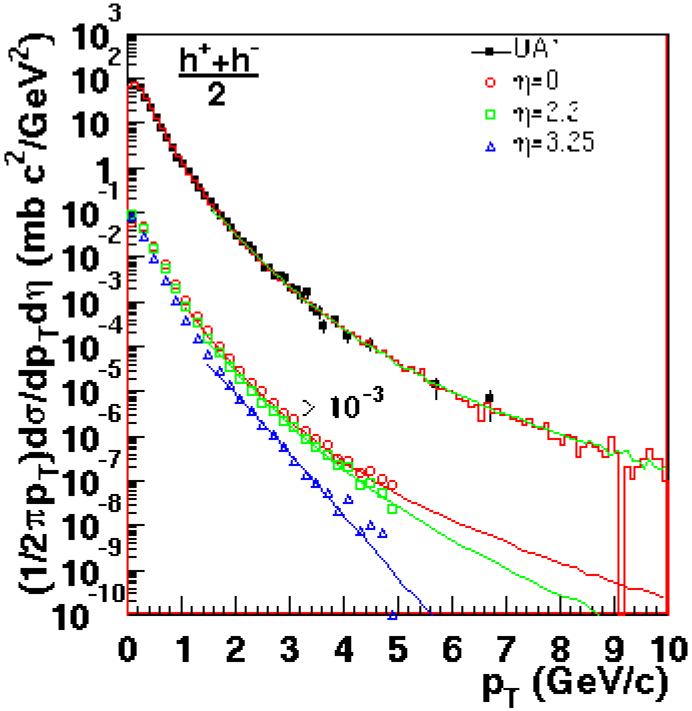
*Initial and final state radiation are included.

$$\boxed{\begin{aligned} E\frac{d\sigma^{pp}_{\text{jet}}}{d^3p} &= K \sum_{ab} \int g(k_{\text{T},a}) d^2 k_{\text{T},a} g(k_{\text{T},b}) d^2 k_{\text{T},b} \\ &\times \int f_a(x_1, Q^2) dx_1 f_b(x_2, Q^2) dx_2 E \frac{d\sigma^{ab\to cd}}{d^3p} \end{aligned}}$$

4. Results from PYTHIA

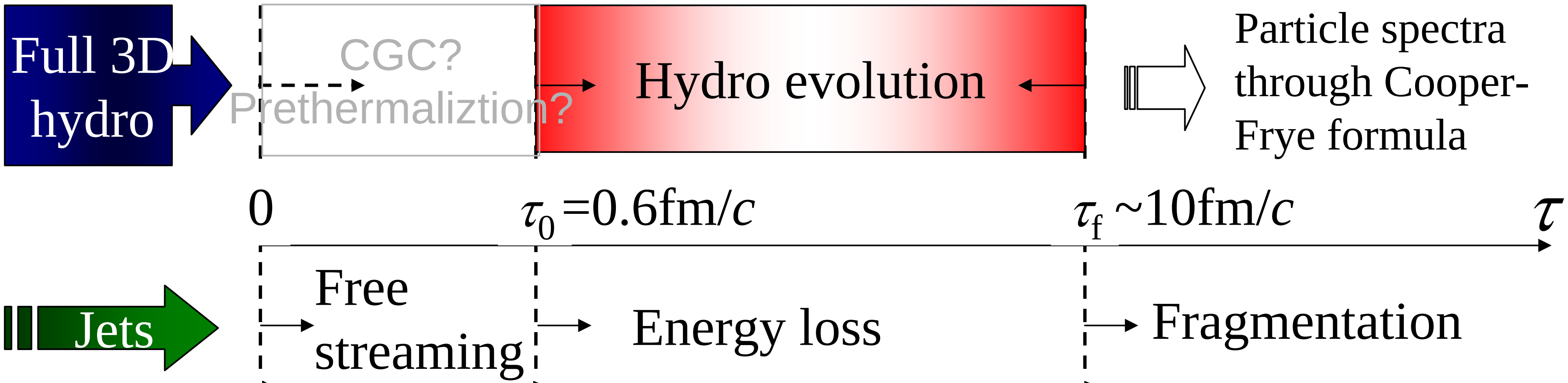


PHENIX π^0
in *pp* collisions@200GeV,
hep-ex/0304038.



UA1 charged
in $p\bar{p}$ collisions@200GeV,
Nucl.Phys.B335, 261(1990).

5. Time Evolution in Hydro+Jet Model



●Formation time~0 fm
For jets with p_T>2GeV/c,
1/p_T<0.1fm/c<<1fm/c

●Momentum dist. from PYTHIA ver. 6.2

●Thermalization time = Initial time of fluids

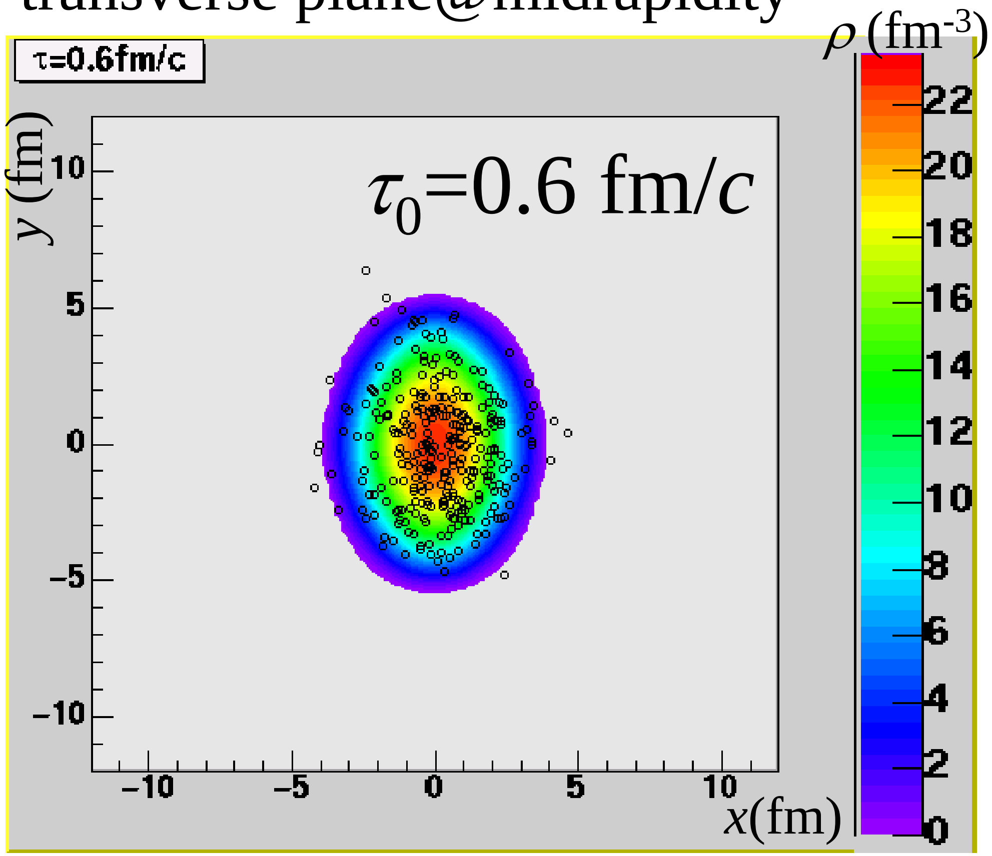
●Initial parameters in hydro have been already tuned.

●After hydro simulation, all survival jets fragment into hadrons.

●We neglect interaction of fragmented hadrons.

6. Initial Condition in the Transverse Plane

Au+Au 200*A*GeV, *b*=8 fm
transverse plane@midrapidity



Gradation
→ *Themalized* parton density
Plot (open circles)
→ Mini-jets (p_T>2GeV/c)

•Initial configuration of mini-jets
→Prop. to # of binary collisions

7. Parton Energy Loss

Relevant for heavy-ion collisions

Simplified GLV formula 1st order in opacity expansion

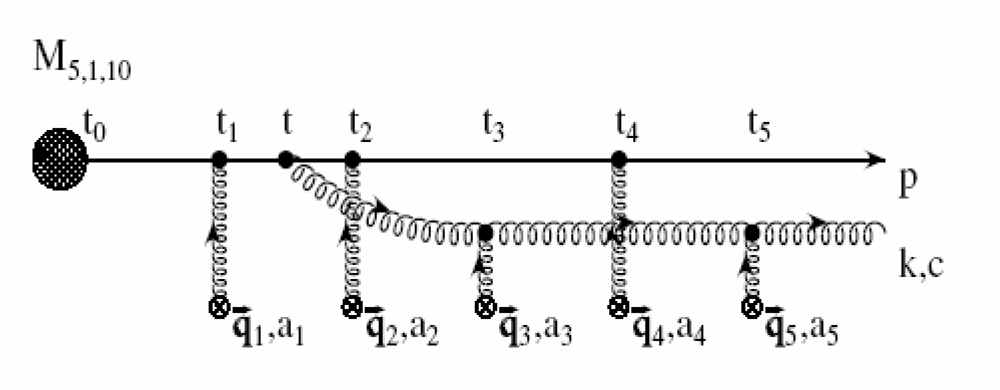
M.Gyulassy *et al*. (2000)

Initial 4-momentum of a jet in local rest frame

Position of a jet

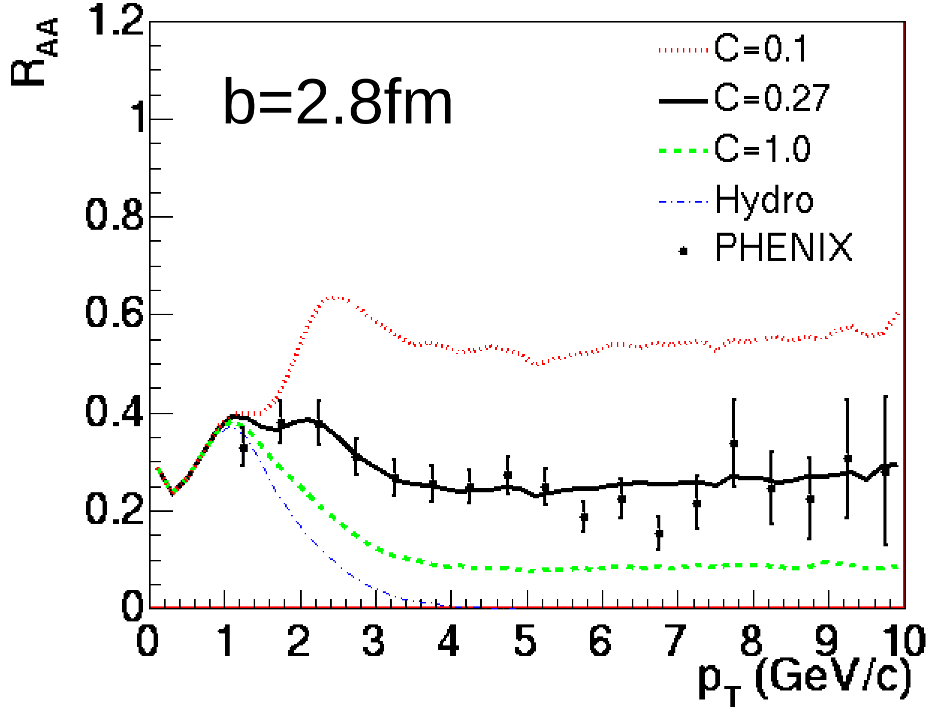
$$\Delta E = -C \int_{\tau_0}^{\infty} d\tau (\tau - \tau_0) \rho\left(\tau, \overline{\mathbf{x}(\tau)}\right) \ln\left(\frac{2p_0^\mu u_\mu}{\mu^2 L}\right)$$

Adjustable parameter



Parton density from hydrodynamic simulations
←We have already had a solution!

8. Suppression Factor for π^0



$$R_{AA} = \frac{dN^{AA}/dp_{\mathrm{T}}d\eta}{\langle N_{\mathrm{coll}}\rangle dN^{pp}/dp_{\mathrm{T}}d\eta}$$

Data from S.S.Adler et al. (PHENIX), PRL91,072301(2003).

Simplified GLV 1st order formula:

$$\Delta E = -C\int_{\tau_0}^{\infty} d\tau(\tau-\tau_0)\rho\left(\tau,\mathbf{x}(\tau)\right)\ln\left(\frac{2p_0^{\mu}u_{\mu}}{\mu^2 L}\right)$$

M.Gyulassy *et al.*, NP**B594**, 371 (2000).

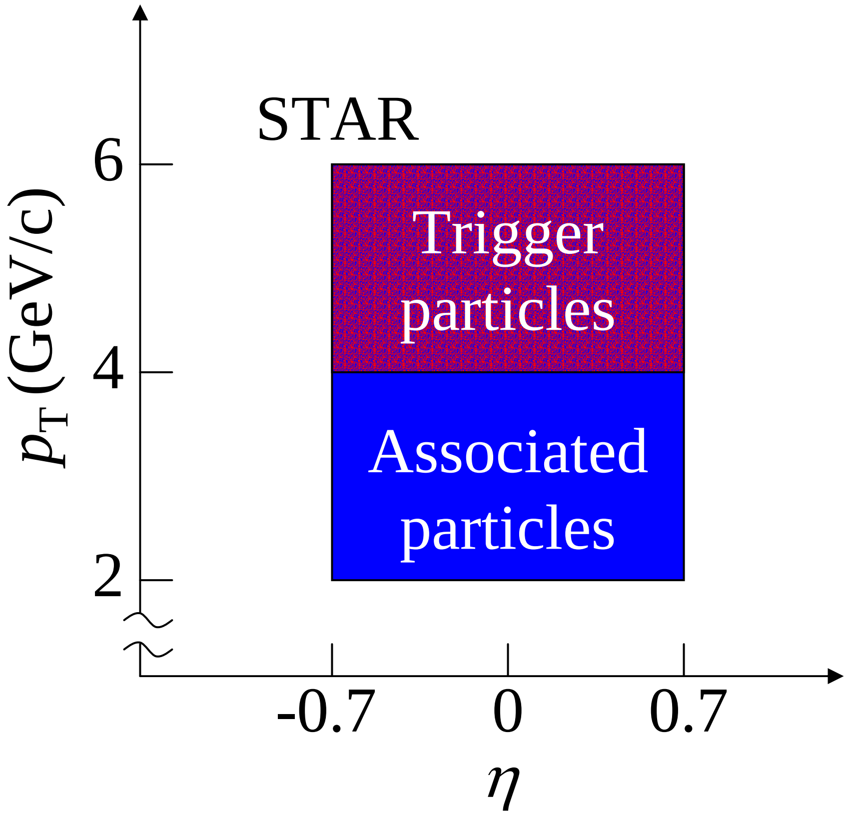
GLV formula with *C*=0.27 quantitatively reproduces the data

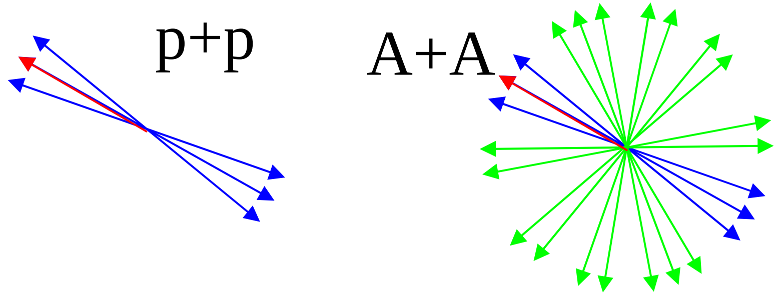
Our starting point of the following discussion

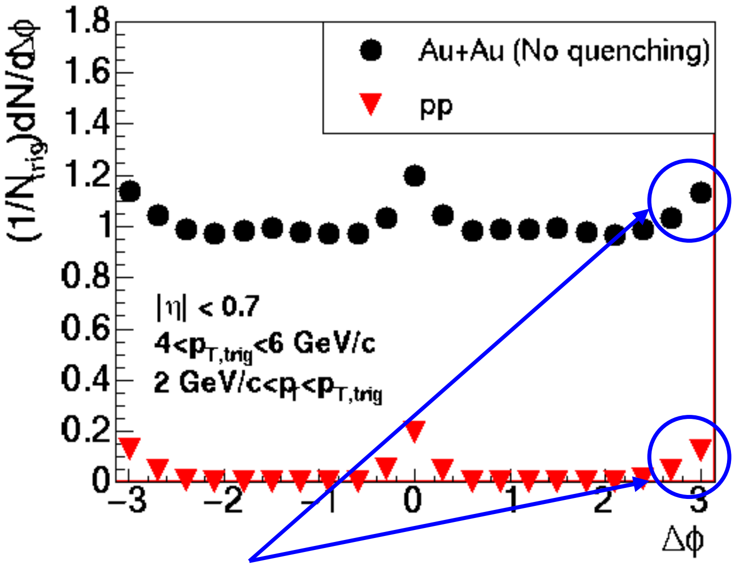
9. Azimuthal Correlation Function

Back-to-back correlations of high p_T hadrons

$$\frac{1}{N_{\rm trig}}\frac{dN}{d\Delta\phi} = \frac{1}{N_{\rm trig}}\int d\Delta\eta \frac{dN}{d\Delta\phi d\Delta\eta}$$

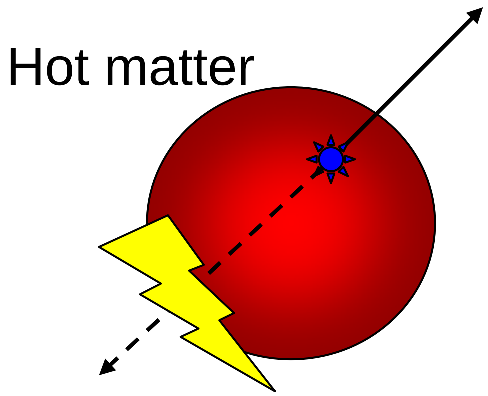
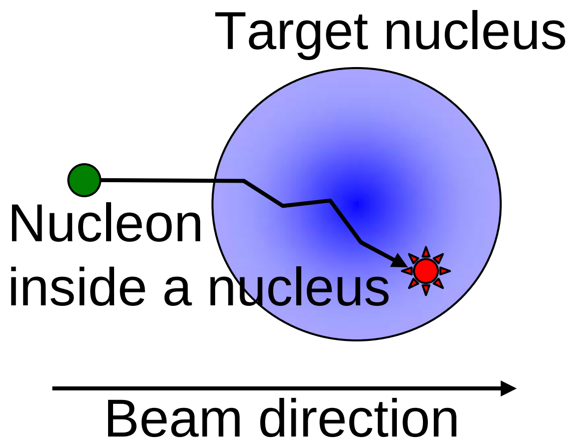
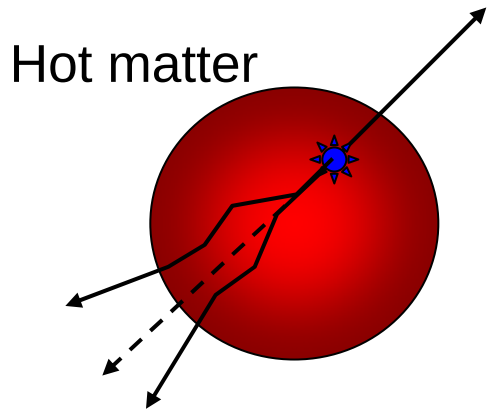




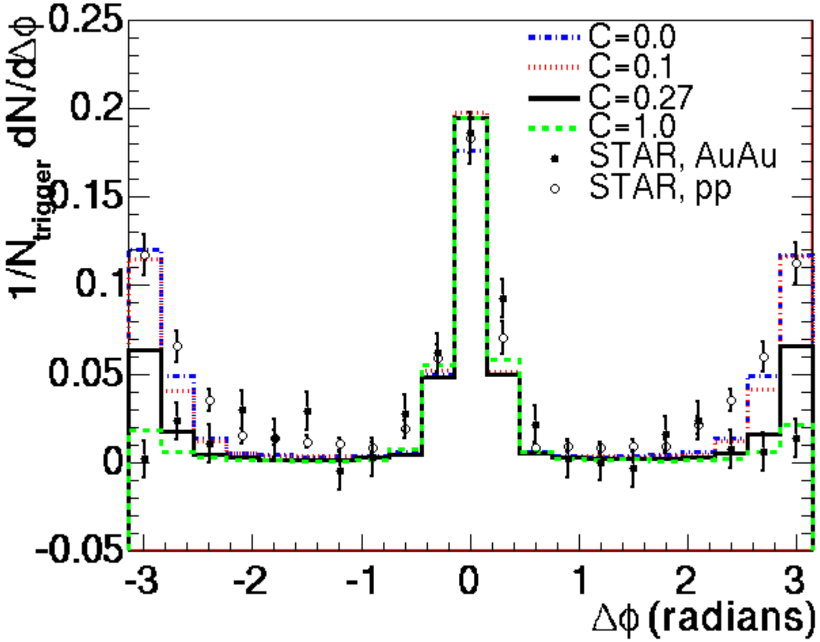


Strength of away-side peaks are the same in no jet quenching case

10. Three Possible Effects on Back-to-back Correlations

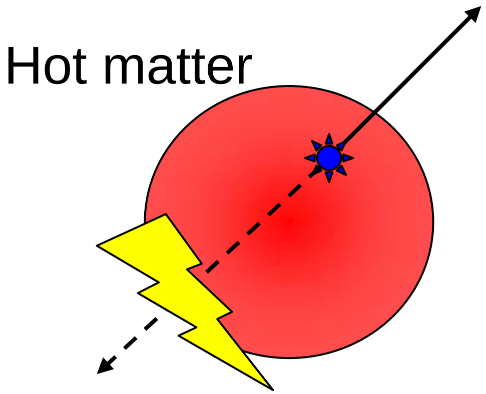
1.Energy loss of jets	2. Primordial k_T of initial partons	3. Broadening of jets
Final state	Initial state	Final state
 Absorption	 “Cronin effect”	 Random walk behavior

11. Effect of Parton Energy Loss



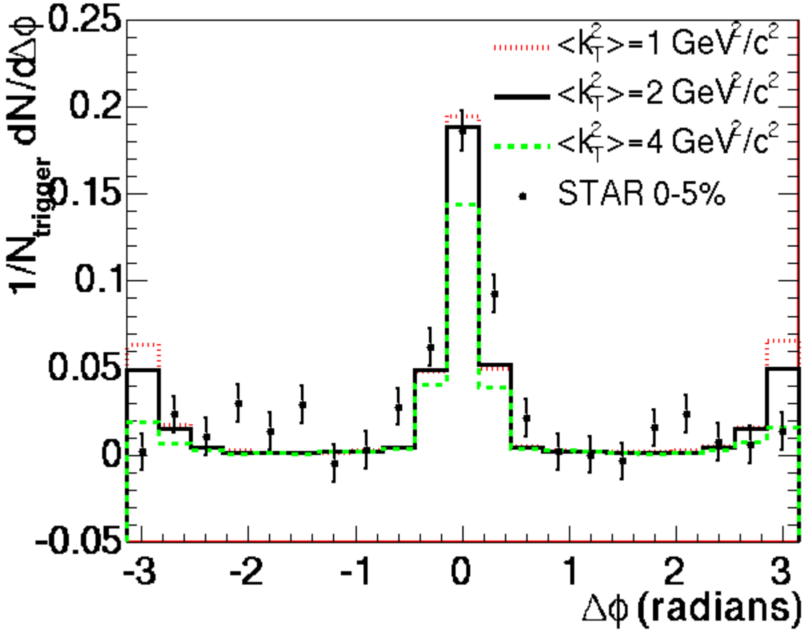
$$\frac{1}{N_{\rm trig}}\frac{dN}{d\Delta\phi} = \frac{1}{N_{\rm trig}}\int d\Delta\eta \frac{dN}{d\Delta\phi d\Delta\eta}$$

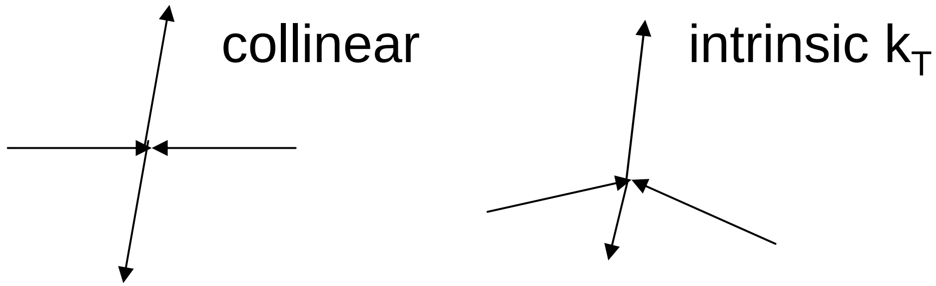
C=0.27 ←From fitting R_{AA}



Simultaneous reproduction of R_{AA} and C_2 ?
→Another mechanism is needed!

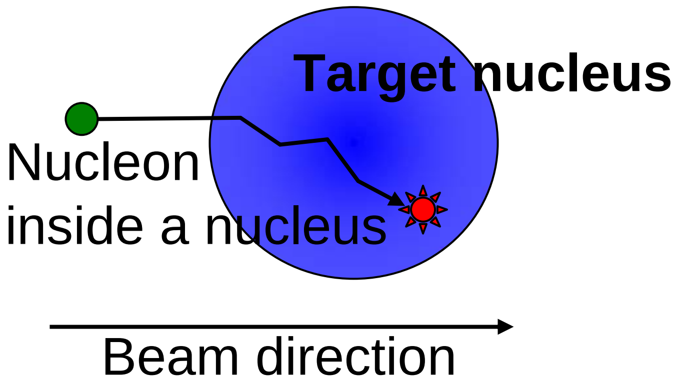
12. Effect of Intrinsic k_T





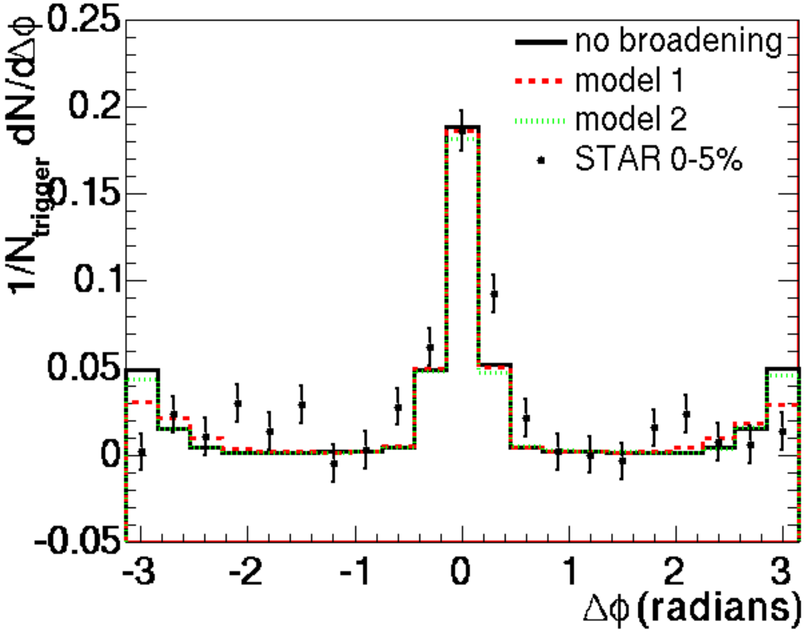
Primordial k_T distribution

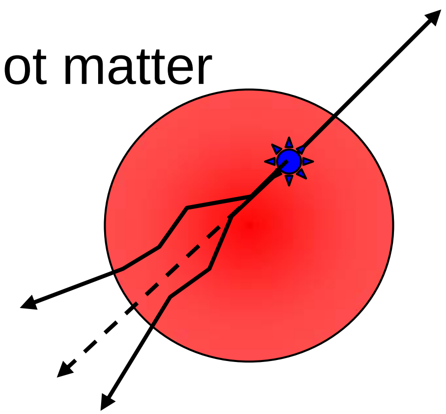
$$g(k_T) \propto \exp(-k_T^2/\sigma_T^2)$$
$$\langle k_T^2 \rangle = \sigma_T^2 = 1, 2 \text{or} 4 \text{GeV}^2/c^2$$
$$(\langle k_T^2 \rangle \sim 2\text{GeV}^2/c^2 \text{@SPS})$$



Intrinsic k_T is insufficient to the disappearance of back-to-back correlation!

13. Effect of Broadening





$p_\perp$: Transverse momentum orthogonal to its direction of motion

Model 1 (BDMPS):

$$\langle p_\perp^2 \rangle = \frac{4}{\alpha_s N_c} \frac{dE}{dx}$$

$$\langle\langle p_\perp^2 \rangle\rangle = 2.5 \ \ \mathrm{GeV}^2/c^2$$

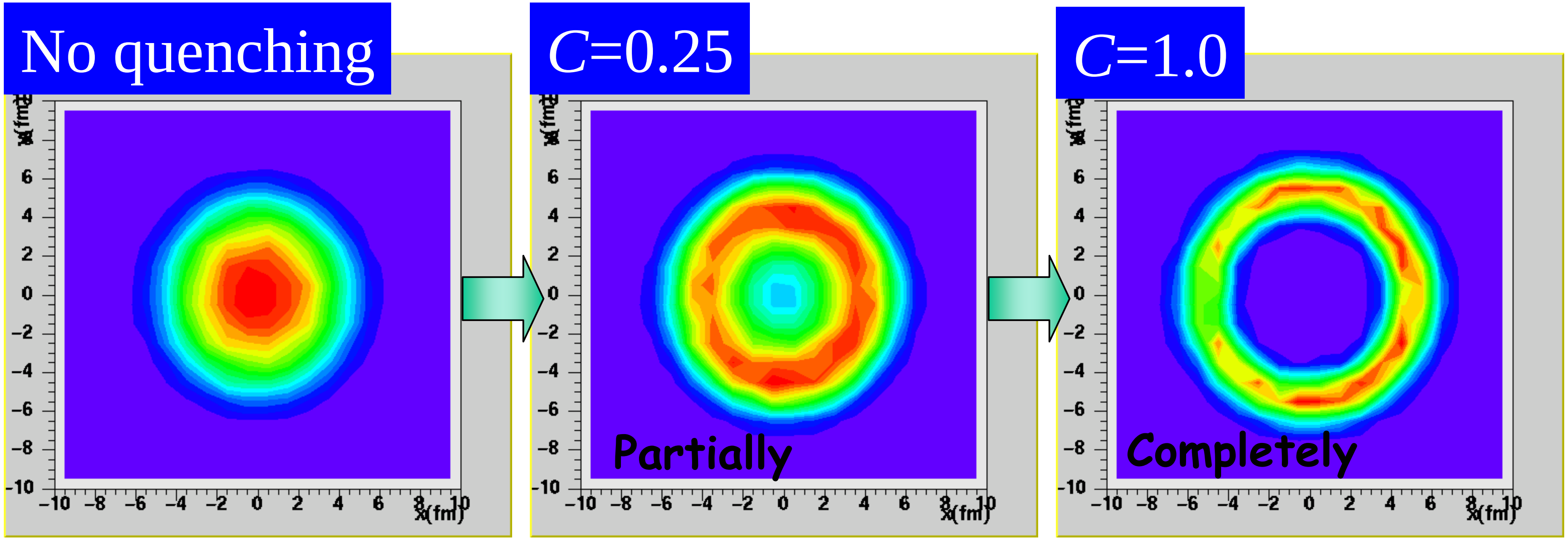
Model 2 (XNW):

$$\langle p_\perp^2 \rangle = (\alpha_s N_c/2)^{-1} C \int \rho d\tau$$

$$\langle\langle p_\perp^2 \rangle\rangle = 0.78 \ \ \mathrm{GeV}^2/c^2$$

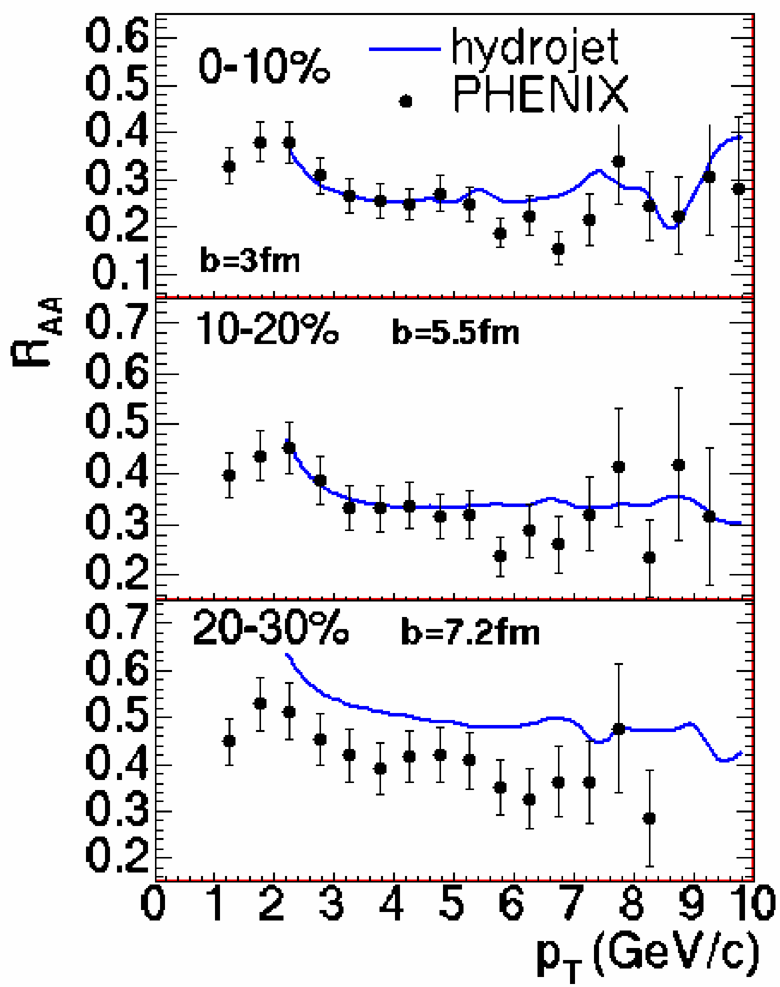
14. Surface Emission Dominance ?

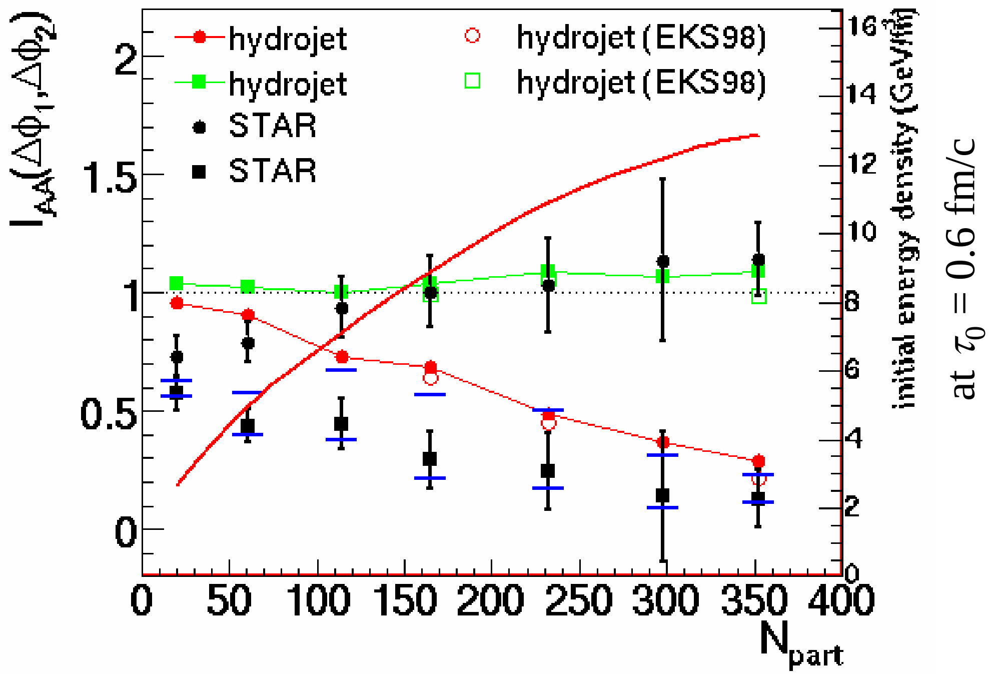
Initial positions of jets which survive at final time



An interesting signature may be events in which the hard collision occurs near the edge of the overlap region, with <u>one jet escaping without absorption and the other fully absorbed</u>. --J.D.Bjorken, FERMILAB-Pub-82/59-THY (1982).

15. Centrality Dependence





16. Summary

Dynamical model (hydro+jet) for heavy-ion physics
Soft: hydrodynamics
(τ-η coordinate, full 3D, separate freezeout T)
Hard: PYTHIA
Parton energy loss: GLV 1st order formula

- Dominant effect of back-to-back correlations

→Parton energy loss
→The effects of intrinsic k_T and p_T broadening are small.

- Centrality dependence

→Good description in b<~5 fm